Leveraging upon standards to build the Internet of Things

KiVi 2014, Eindhoven

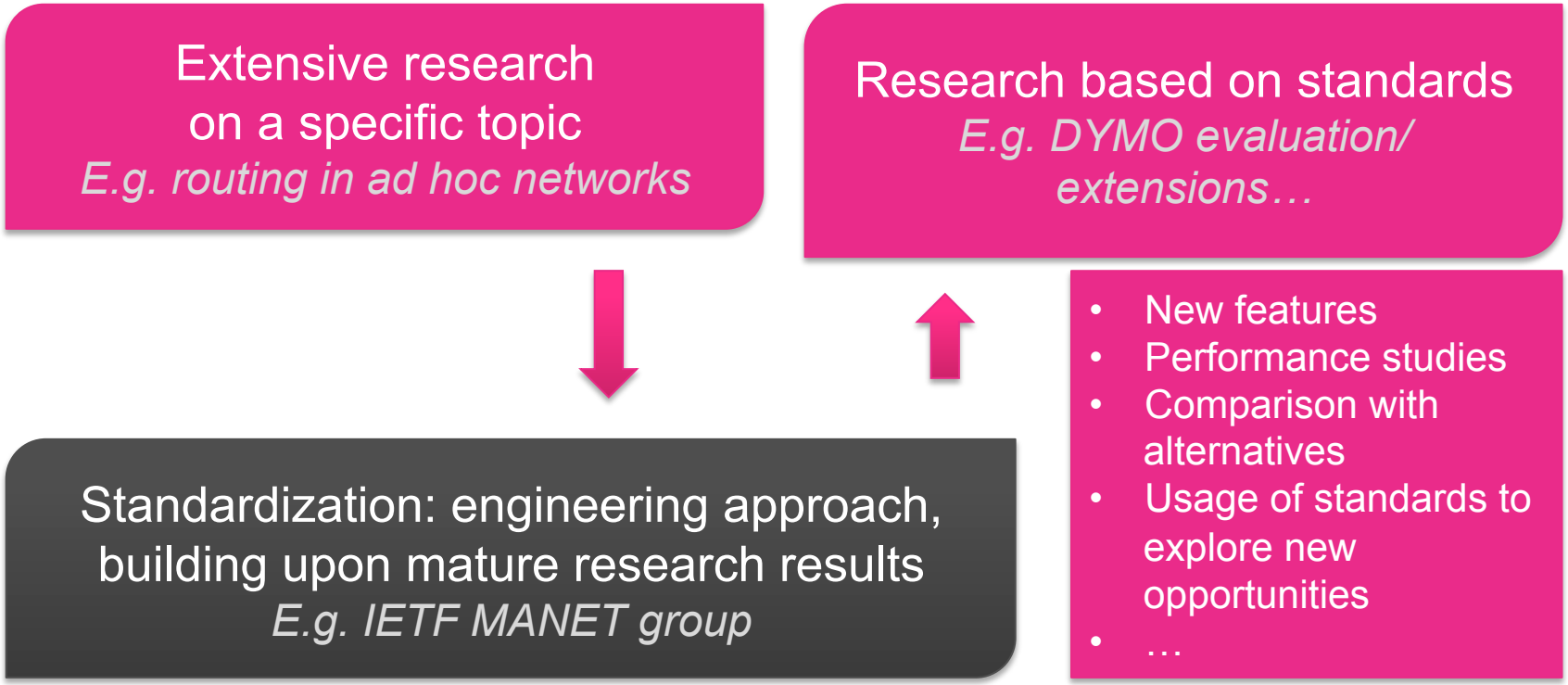
Ingrid Moerman
Ingrid.moerman@intec.ugent.be

Jeroen Hoebeke
Jeroen.hoebeke@intec.ugent.be

www.ibcn.intec.ugent.be
Internet Based Communication Networks and Services (IBCN)
Department of Information Technology (INTEC)
Ghent University - iMinds

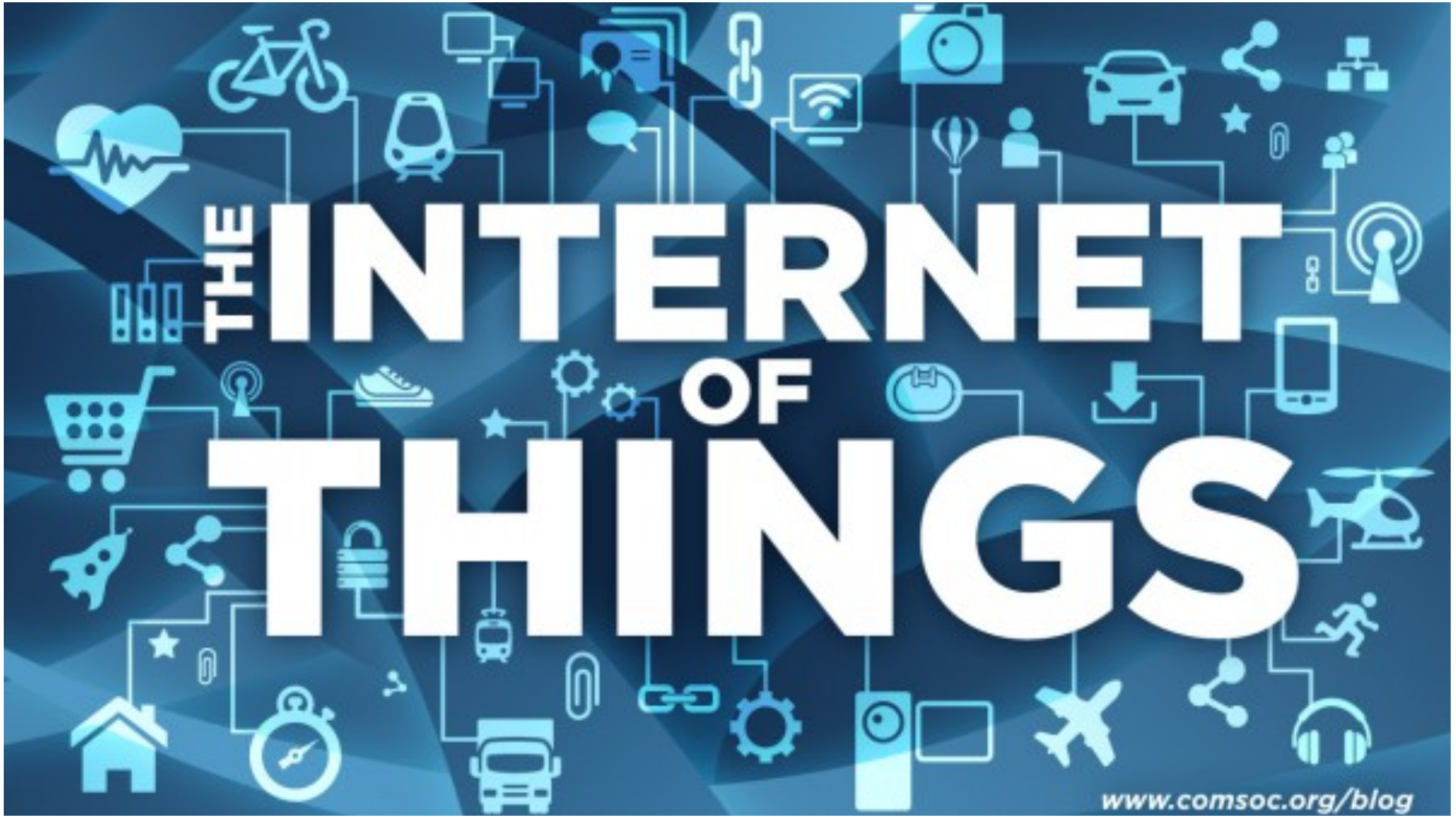
Interaction research - standardization

- Common pattern



- Today: applied to Internet of Things

Today

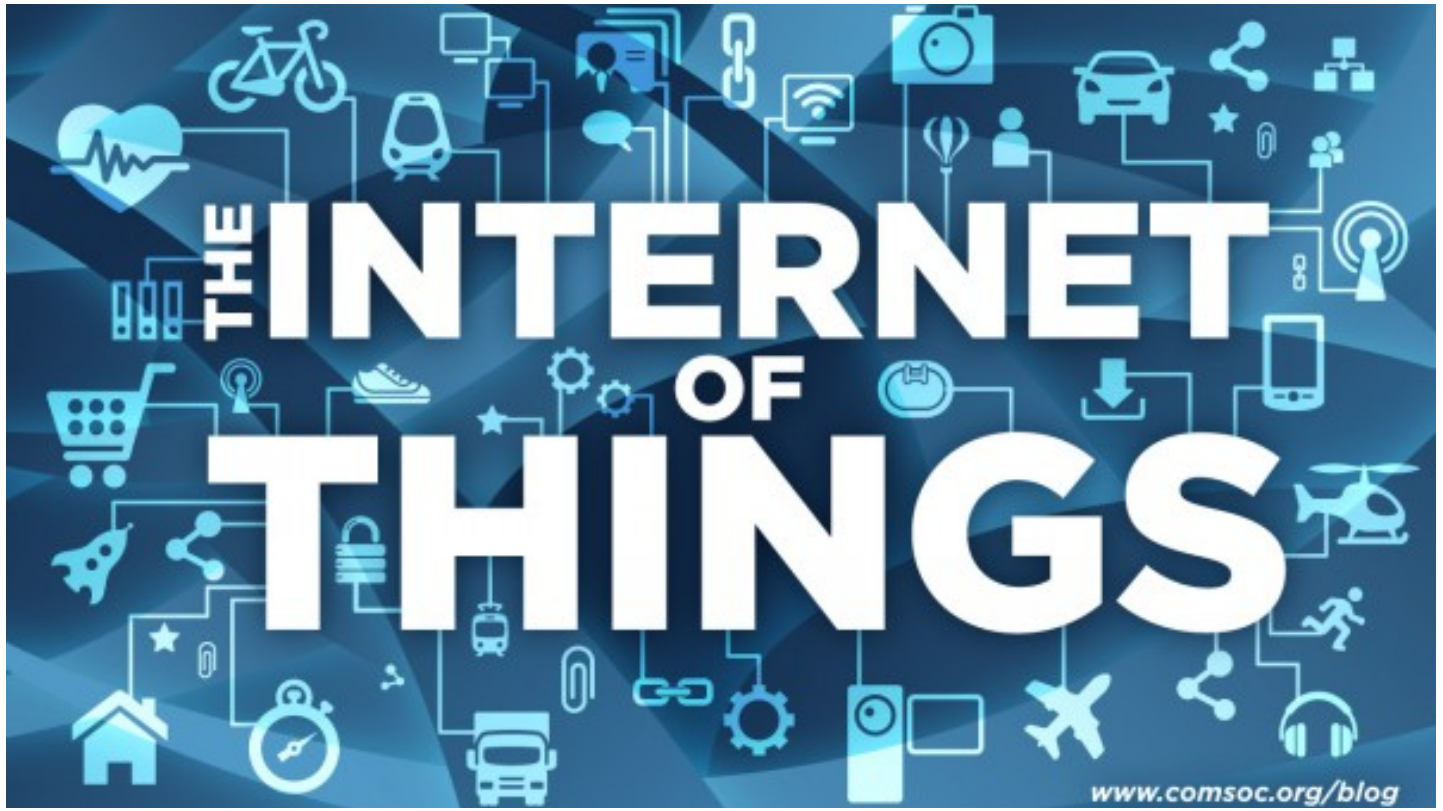


Today

INTERNET of THINGS (IoT)
= everyday physical objects connected to the Internet able to identify themselves to other devices

data created by PERSONS → data created by THINGS

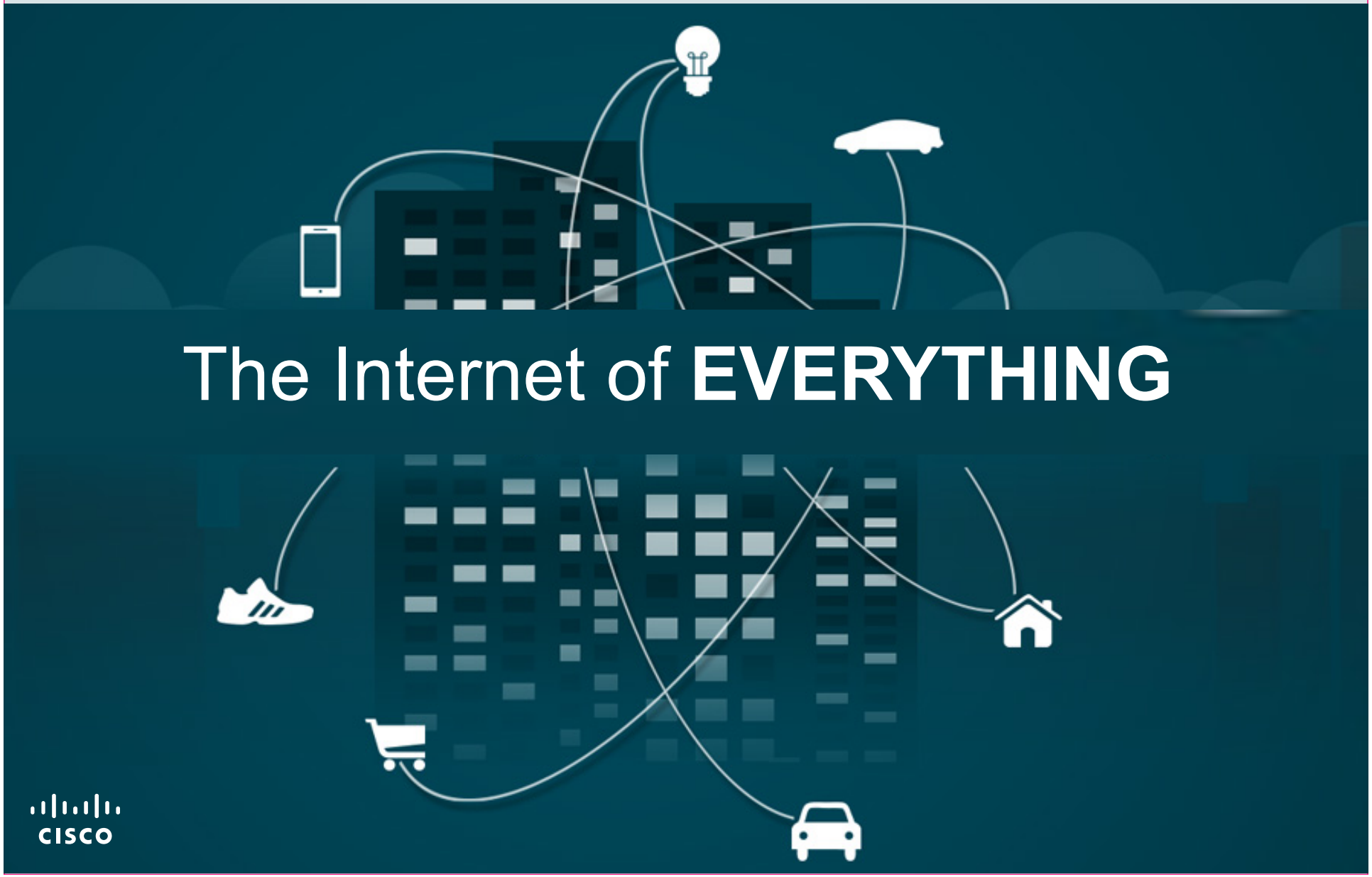
Today



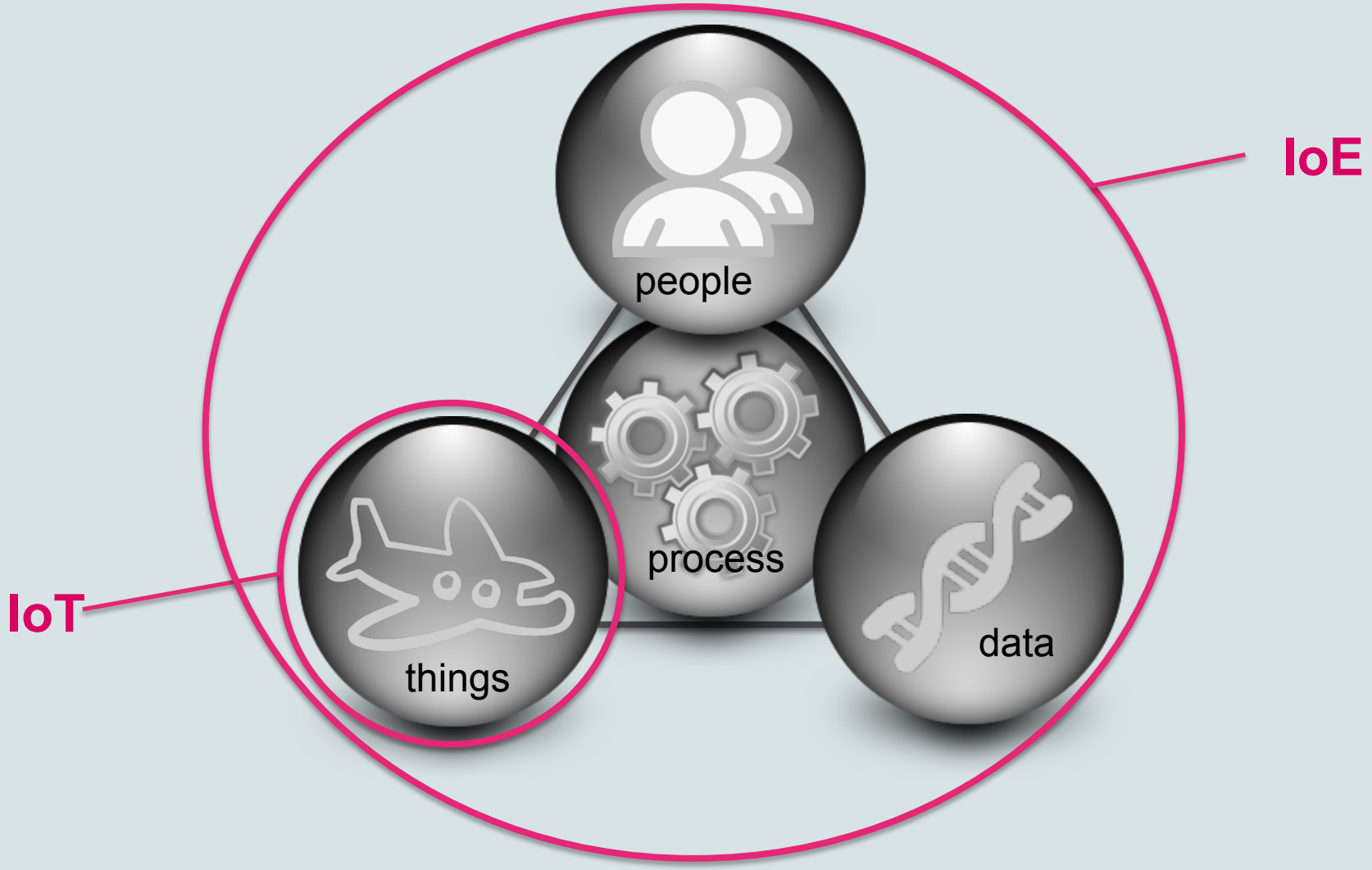
Heterogeneous objects (sensors, actuators…) reveal information about the physical world, inject it into the virtual world (Internet) where it can be used as input to services, which can act again upon the physical world.

= Uniquely identifiable things with a virtual representation

Tomorrow



Internet of Everything



Networked connection of people, things, data, and process

INTERNET of EVERYTHING (IoE)

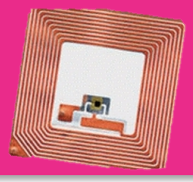
= networked connection of people, things, data, and process

= intelligent decisions

A little history of IoT progress

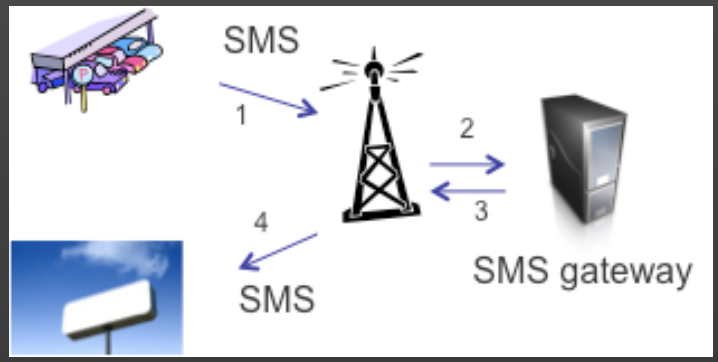
Radio-frequency identification

- *Equip objects with tags, read radio tags, identify and inventory*
- *First use of IoT (1999)*



Machine-to-machine (M2M)

- *One device = one SIM card*
- *Operator managed access + communication through server*



Internet of Things (IoT)

- *One device = one IP address*
- *Internet-based device access: operator = transport network*
- *Direct interactions, flexible applications over multiple communication technologies*

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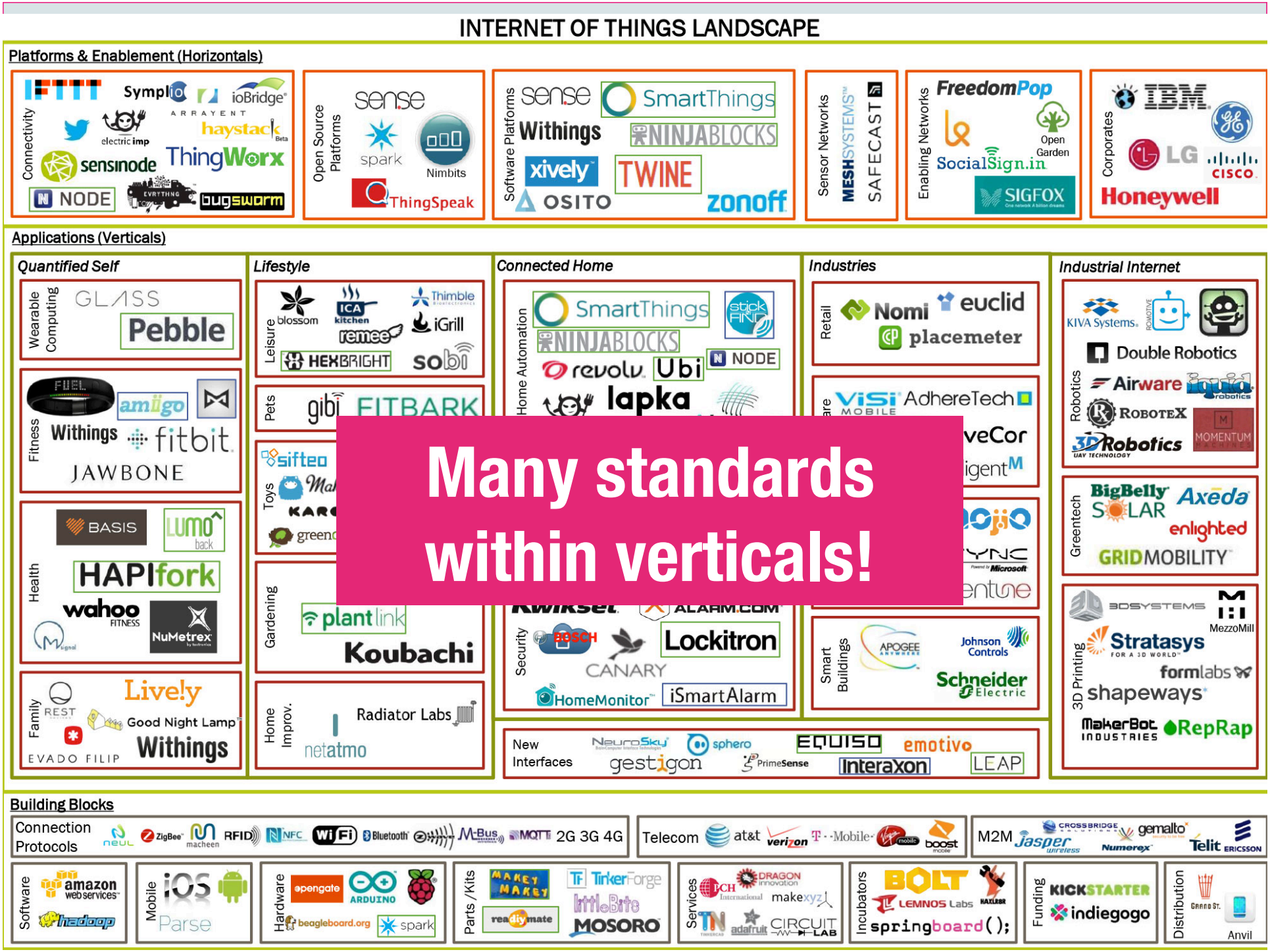
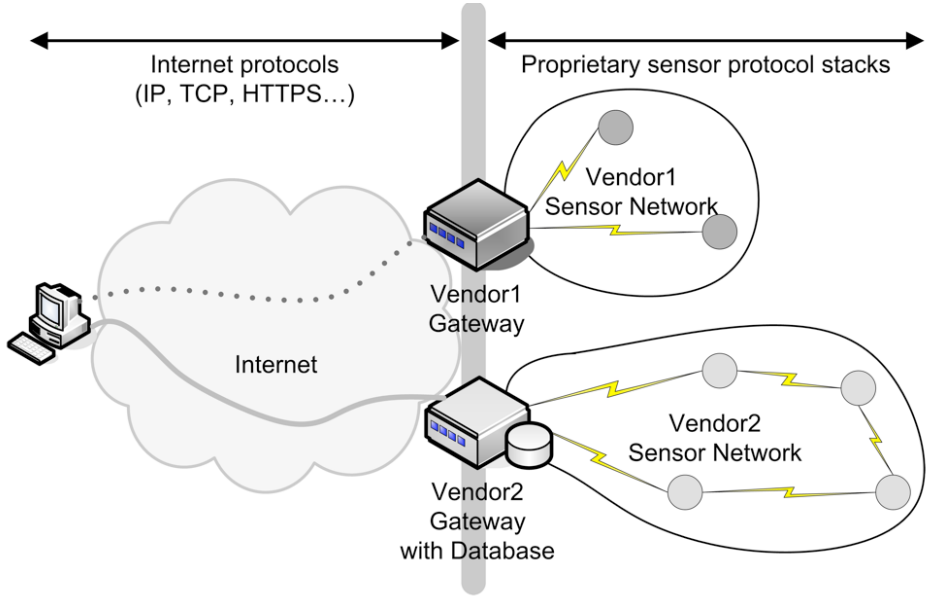

INTERNET OF THINGS LANDSCAPE
Platforms & Enablement (Horizontals)
Connectivity
IFTTT
Sympl
ioBridge
ARRAYENT
electric imp
haystack
sensinode
ThingWorx
NODE
bugswarm
Open Source Platforms
sense
spark
Nimbits
ThingSpeak
Software Platforms
sense
SmartThings
Withings
NINJABLOCKS
xively
TWINE
OSITO
zonoff
Sensor Networks
MESHSYSTEMS
SAFECAST
Enabling Networks
FreedomPop
Open Garden
SocialSign.in
SIGFOX
Corporates
IBM
LG
CISCO
Honeywell
Applications (Verticals)
Quantified Self
Wearable Computing
GLASS
Pebble
Fitness
amiigo
Withings
fitbit
JAWBONE
Health
BASIS
LUMOback
HAPIfork
wahoo FITNESS
NuMetrex
Family
REST
Lively
Good Night Lamp
EVADO FILIP
Withings
Lifestyle
Leisure
blossom
ICA kitchen
Thimble
remee
iGrill
HEXBRIGHT
sobi
Pets
gibi
FITBARK
Toys
sifteo
KARO
Gardening
plantlink
Koubachi
Home Improv.
Radiator Labs
netatmo
Connected Home
Home Automation
SmartThings
stickNFIND
NINJABLOCKS
revolv
Ubi
NODE
lapka
Security
BOSCH
Lockitron
CANARY
HomeMonitor
iSmartAlarm
ALARM.COM
New Interfaces
NeuroSky
sphero
EQUISO
emotivo
gestigon
PrimeSense
InteraXon
LEAP
Industries
Retail
Nomi
euclid
placemeter
AdhereTech
Smart Buildings
APOGEE
Johnson Controls
Schneider Electric
Industrial Internet
KIVA Systems
Double Robotics
Robotics
Airware
ROBOTEX
3D Robotics
MOMENTUM MACHINES
Greentech
BigBelly SOLAR
Axeda
enlighted
GRIDMOBILITY
3D Printing
3DSYSTEMS
MezzoMill
Stratasys
formlabs
shapeways
MakerBot INDUSTRIES
RepRap
Many standards within verticals!
Building Blocks
Connection Protocols
neul
ZigBee
macheen
RFID
NFC
Wi Fi
Bluetooth
MBus
MQTT
2G 3G 4G
Telecom
at&t
verizon
T-Mobile
boost mobile
M2M
CROSSBRIDGE
Jasper wireless
gemalto
Numerex
Telit
ERICSSON
Software
amazon web services
hadoop
Mobile
iOS
Parse
Hardware
opengate
ARDUINO
beagleboard.org
spark
Parts /Kits
MAKEY MAKEY
TinkerForge
littleBits
MOSORO
Services
DRAGON innovation
makexyz
adafruit
CIRCUIT LAB
Incubators
BOLT
LEMNOS Labs
springboard();
Funding
KICKSTARTER
indiegogo
Distribution
GRAND ST.
Anvil

A little history of IoT progress

- Internet integration: from proprietary stacks...



- … to IP-based integration

"Success in extending IP functionality to literally billions of devices absolutely requires a framework of standards that defines the necessary technology ecosystem" – CEO Sensinode –

Importance of open standards in IoT

IoE
What will it take?

From Proprietary Standards...

…to Open Standards

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Importance of open standards in IoT

cisco

IoE
What will it take?

From Proprietary Standards...

…to Open Standards

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Today

- **Still many different standards within verticals**

enocean

Z-Wave

ZigBee
Control your world

LonWorks

- **Upcoming IoT initiatives**

ALLSEEN ALLIANCE

Qeo

Importance of open standards in IoT

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IoE
What will it take?

From Proprietary Standards...

…to Open Standards

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Today

The Internet runs on IETF protocols: IP, TCP, HTTP…

Trend towards all-IP, also for constrained devices

Trend towards web services

I E T F®

Will play/plays a major role in IoT

Importance of open standards in IoT

IoE
What will it take?

From Proprietary Standards...

...to Open Standards

Open standards for constrained devices

CoAP	IETF CoRE
UDP	
6LoWPAN	IETF RPL IETF 6LoWPAN
802.15.4	IEEE

92KB flash
8KB RAM

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Importance of open standards in IoT

- Standards tailored to constrained devices (focus on IETF)
  - Physical layer:
    - **IEEE 802.15.4**
  - Network layer: integration in IPv6 world
    - **IETF 6LoWPAN**: IPv6 over Low power WPAN
    - **IETF ROLL**: Routing over Low power and Lossy networks (LLNs)
    - **IETF CoRE**: Constrained RESTful Environments

Importance of open standards in IoT

CISCO

IoE
What will it take?

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IETF

Open standards for constrained devices

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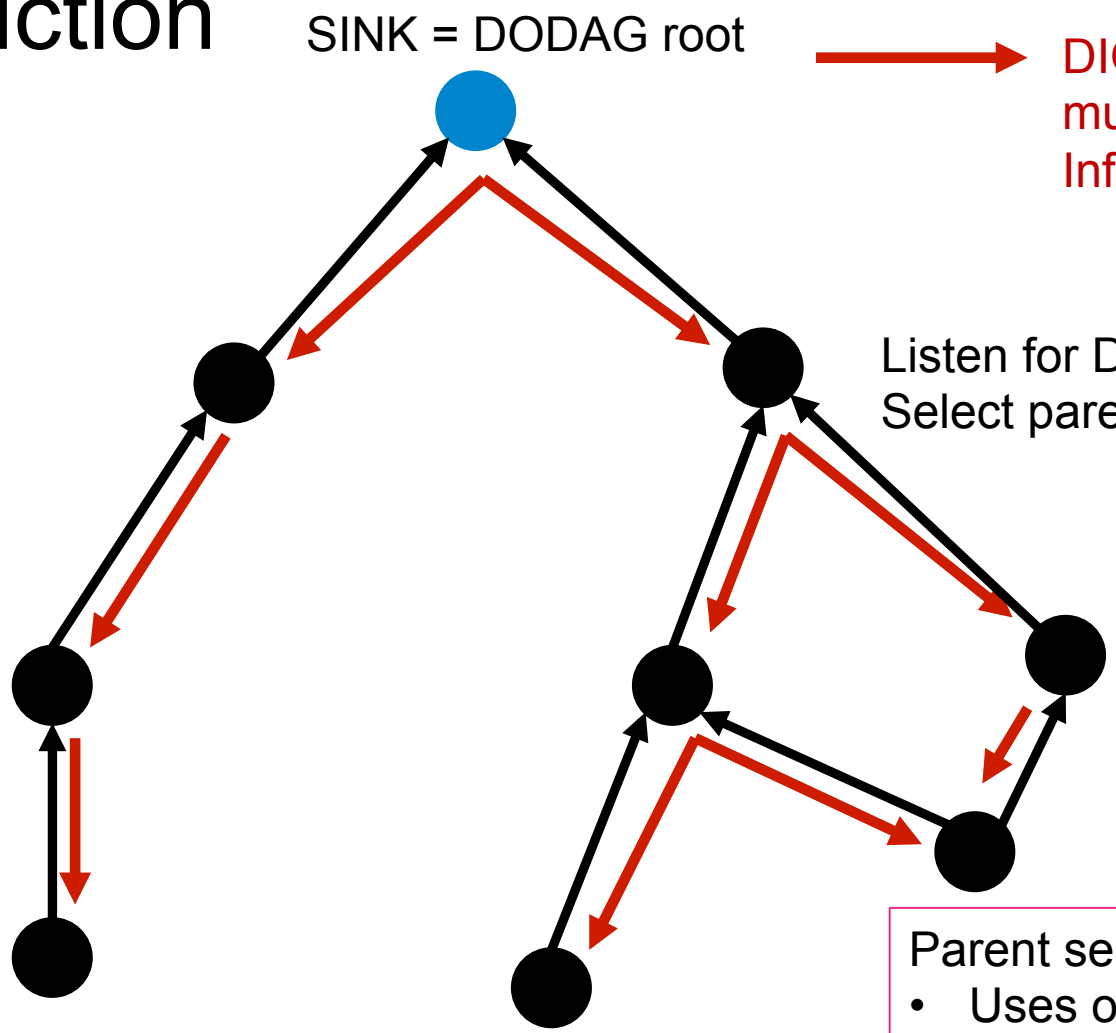
IETF Roll group

- Building routing solutions for LLNs
  - Energy-efficient, limited link-layer frame size, limited RAM/ROM usage, other communication paradigms (e.g. multipoint-to-point)… : ~~existing protocols?~~

- IPv6 Routing Protocol for LLNs (RPL)
  - Optimized for traffic to or from roots/sinks (multipoint-to-point + point-to-multipoint support)
  - Characteristics:
    - Create Destination Oriented Directed Acyclic Graphs (DODAGs)
    - Destination Advertisement Objects (DAO) for downward routes

RPL: Upward routes and DODAG construction

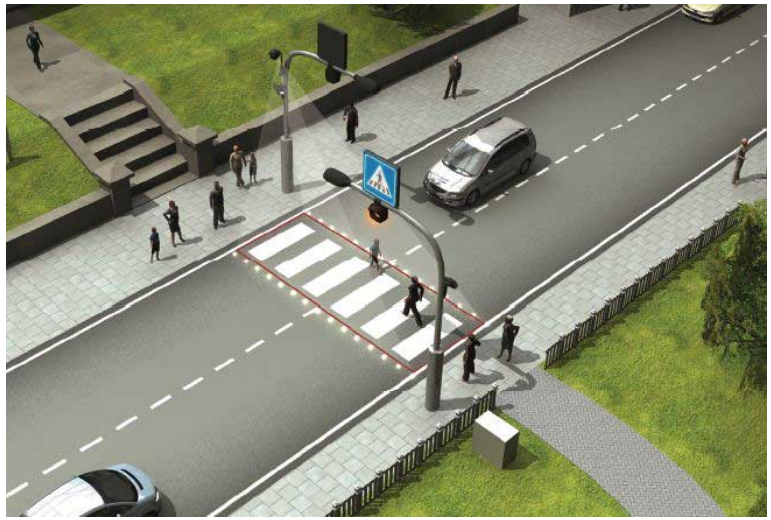


Parent selection:
- Uses objective function
- Based on link quality: ETX metric

Parent switching possible

Add mobility support to RPL

- Why?: ITS use case "vulnerable road users"
  - RSU = sink, users = sensors
  - "Collect" presence
  - Energy efficient, look at sensor protocols



- RPL:
  - Reacts on topology changes
  - Too slow for real mobility support

Importance of open standards in IoT

CISCO

IoE
What will it take?

From Proprietary Standards...

...to Open Standards

IETF

Open standards for constrained devices

CoAP	IETF CoRE
UDP	
6LoWPAN	IETF RPL IETF 6LoWPAN
802.15.4	IEEE

92KB flash
8KB RAM

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IETF CoRE

- Success of today's Internet? Web services
  - Not suited for constrained networks/LLNs
    - Constraints, different interaction models (short exchanges, sleeping nodes…)
- Embedded counterpart needed

- ➔ IETF CoRE group: design of an application transfer protocol that realizes a minimal subset of REST along with resource discovery, subscription/notification and the use of security measures

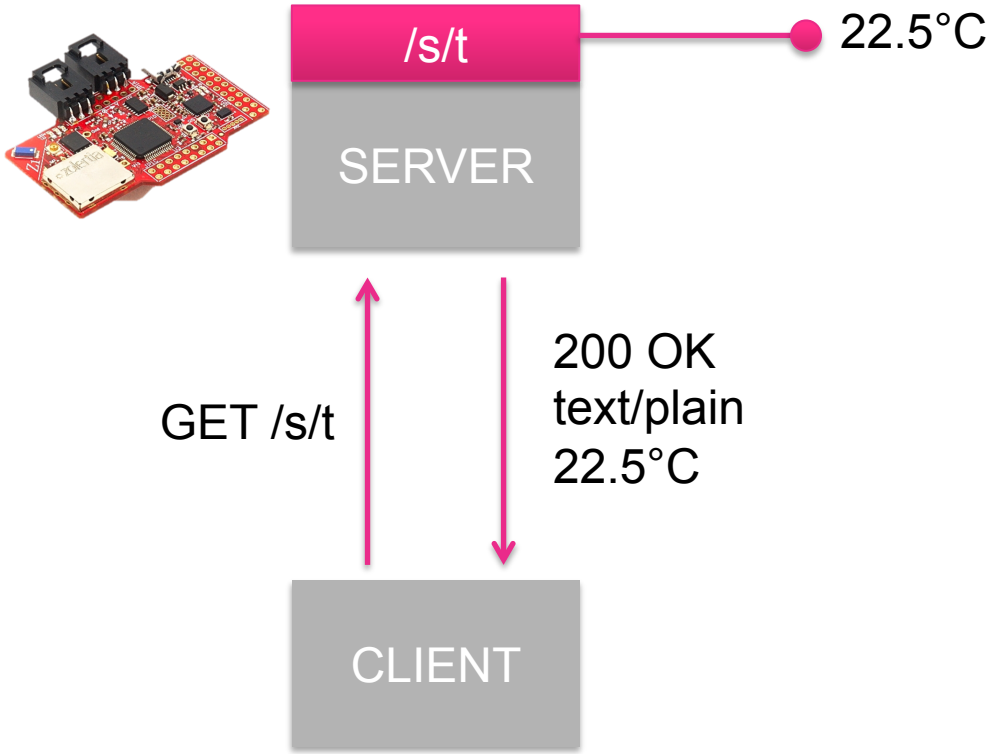
Note: Representational state transfer (REST)
Transfer of the representation of resources
Typically: HTTP (GET, PUT, POST, DELETE)

IETF CoRE - CoAP

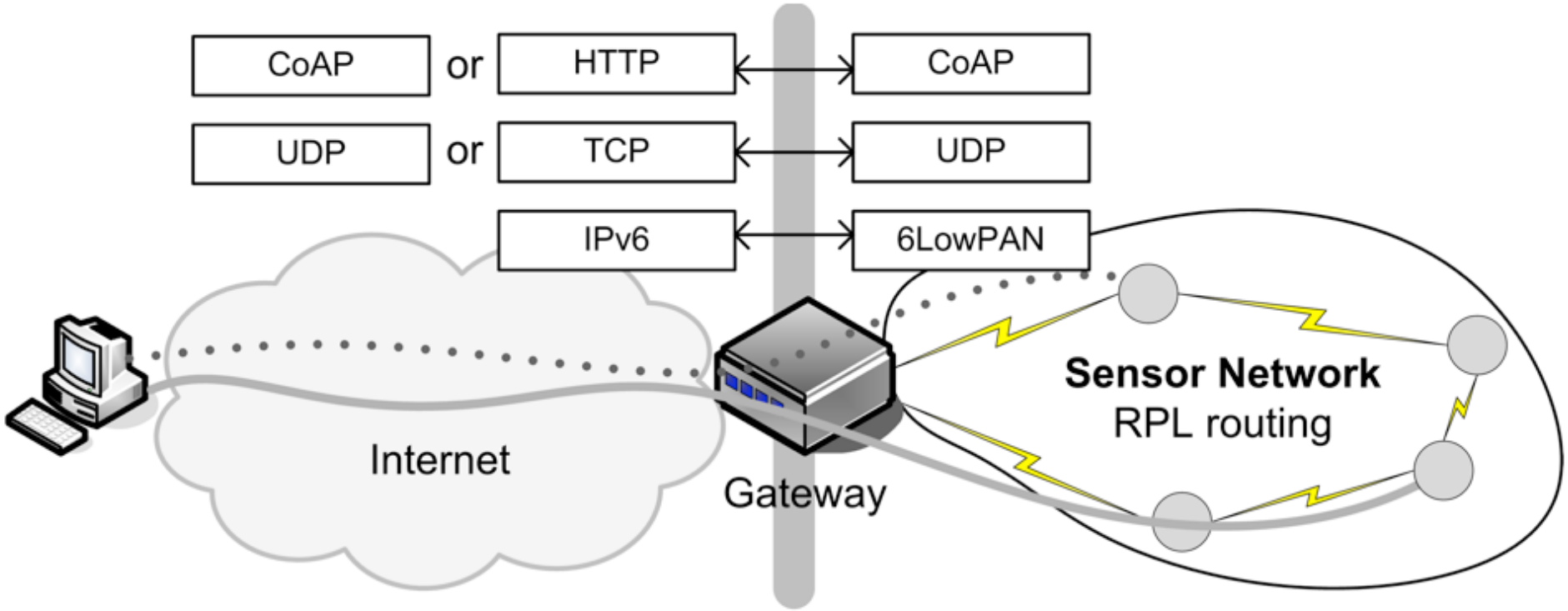
- Constrained Application Protocol (CoAP)
  - Embedded version of HTTP
  - Features:
    - Asynchronous transaction model
    - UDP with reliability and multicast support
    - GET, PUT, POST and DELETE using URIs
    - Small, simple header: 4 bytes base header + TLV options
    - Mapping to HTTP possible
    - coap:// scheme
    - Optional observation, block transfer and resource discovery

IoT standardization: IETF CoRE

- CoRE = Constrained RESTful environments
- Design of Constrained Application Protocol (CoAP)

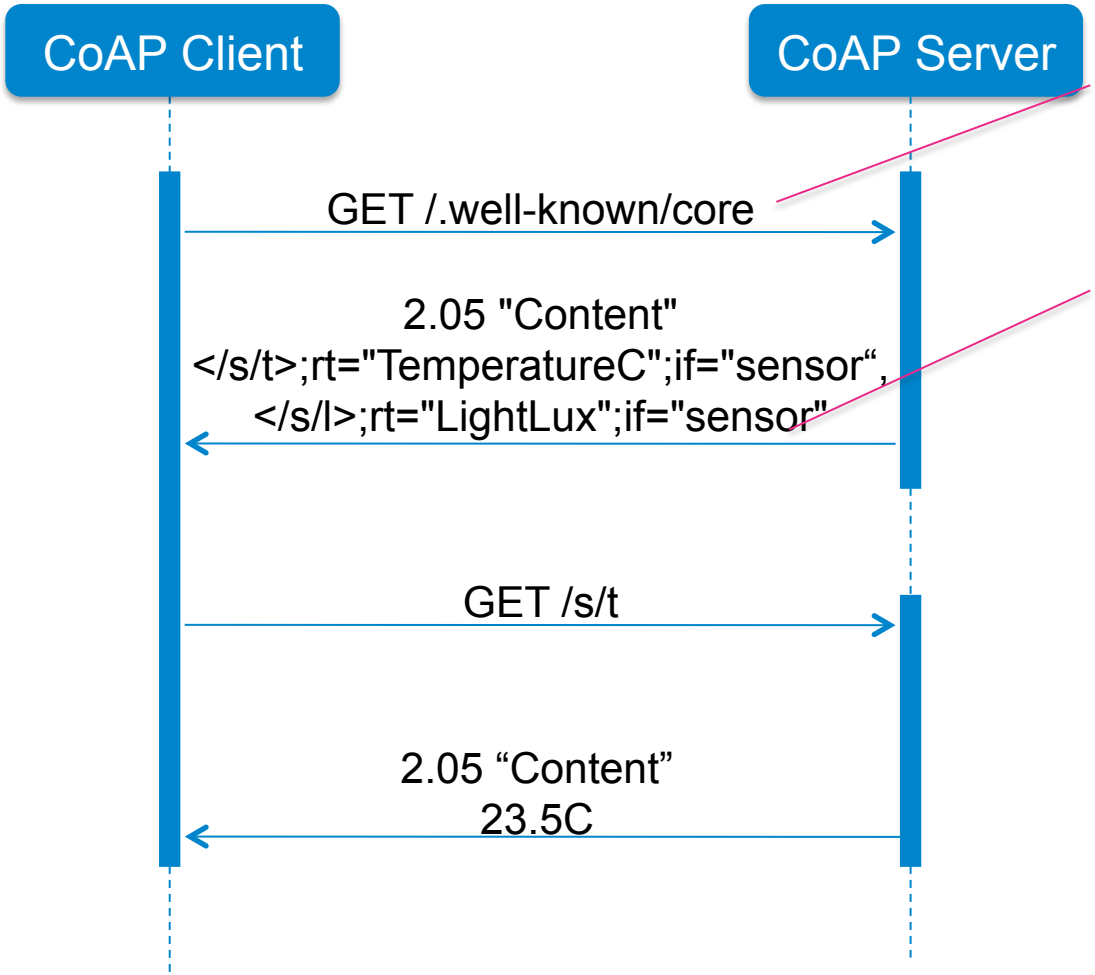


CoAP architecture



- Goal: provide RESTful access to resource constrained devices
  - Similar to HTTP (get, put, post, …)
  - Suitable for **direct end-to-end communication** between constrained devices

CoAP example



Resource /.well-known/core used for **resource discovery**

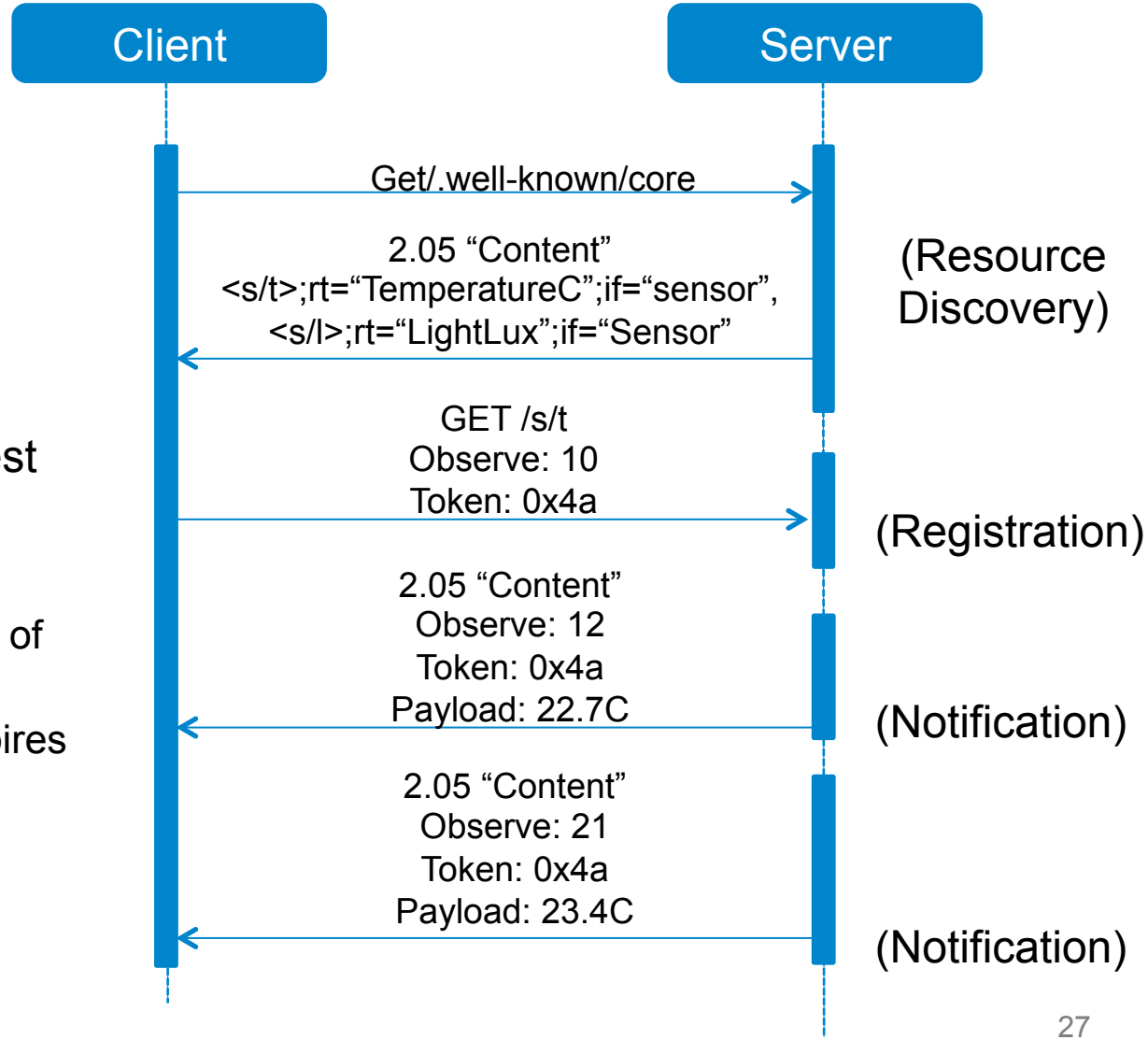
Result = collection of resources in "application/link-format"

- URI reference
- Target **attributes**: describe information useful to access the resource

➔ coap://[IPv6_sensor]/s/t exists

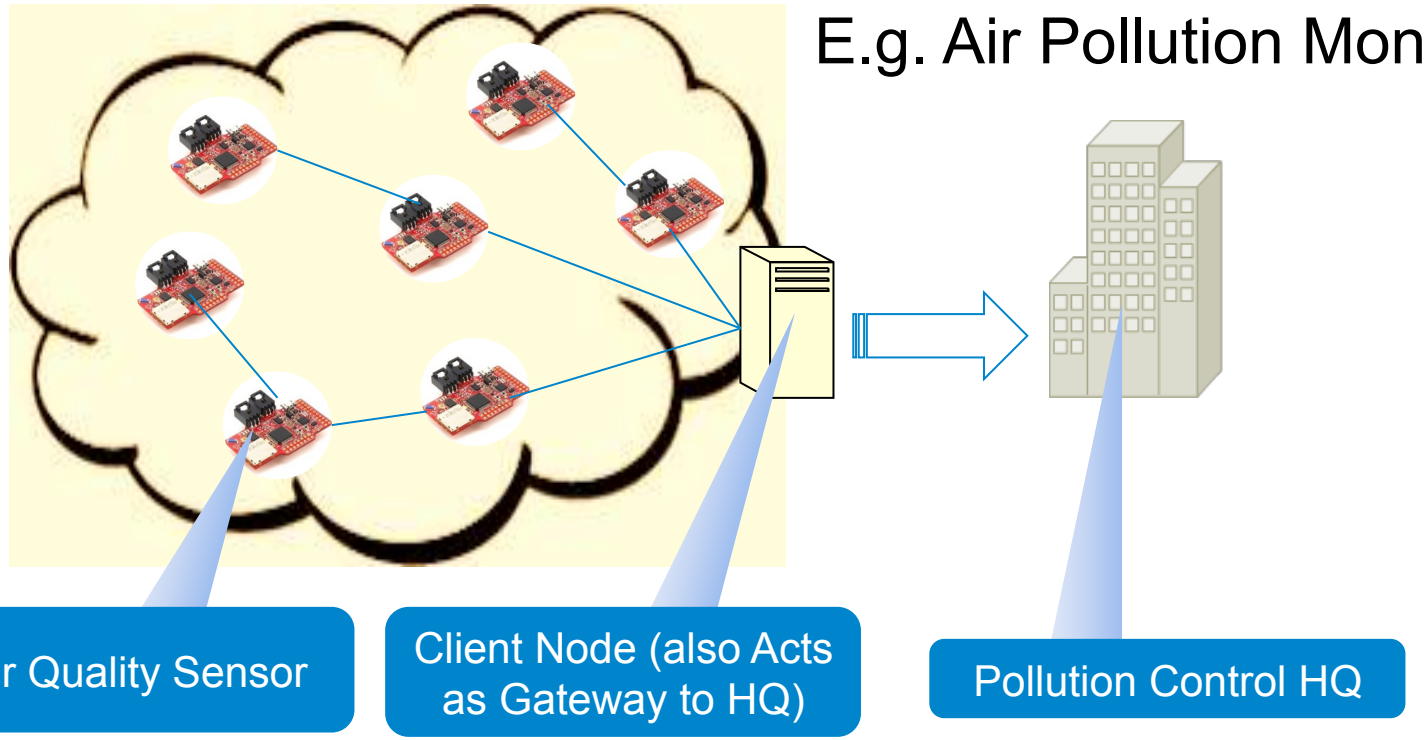
CoAP Observe option

- Client can register interest for having an always fresh representation of a resource: send request with observe option
- Notifications upon
  - Every state change of resource
  - When max-age expires (for freshness)



CoAP Observe Limitations

E.g. Air Pollution Monitoring

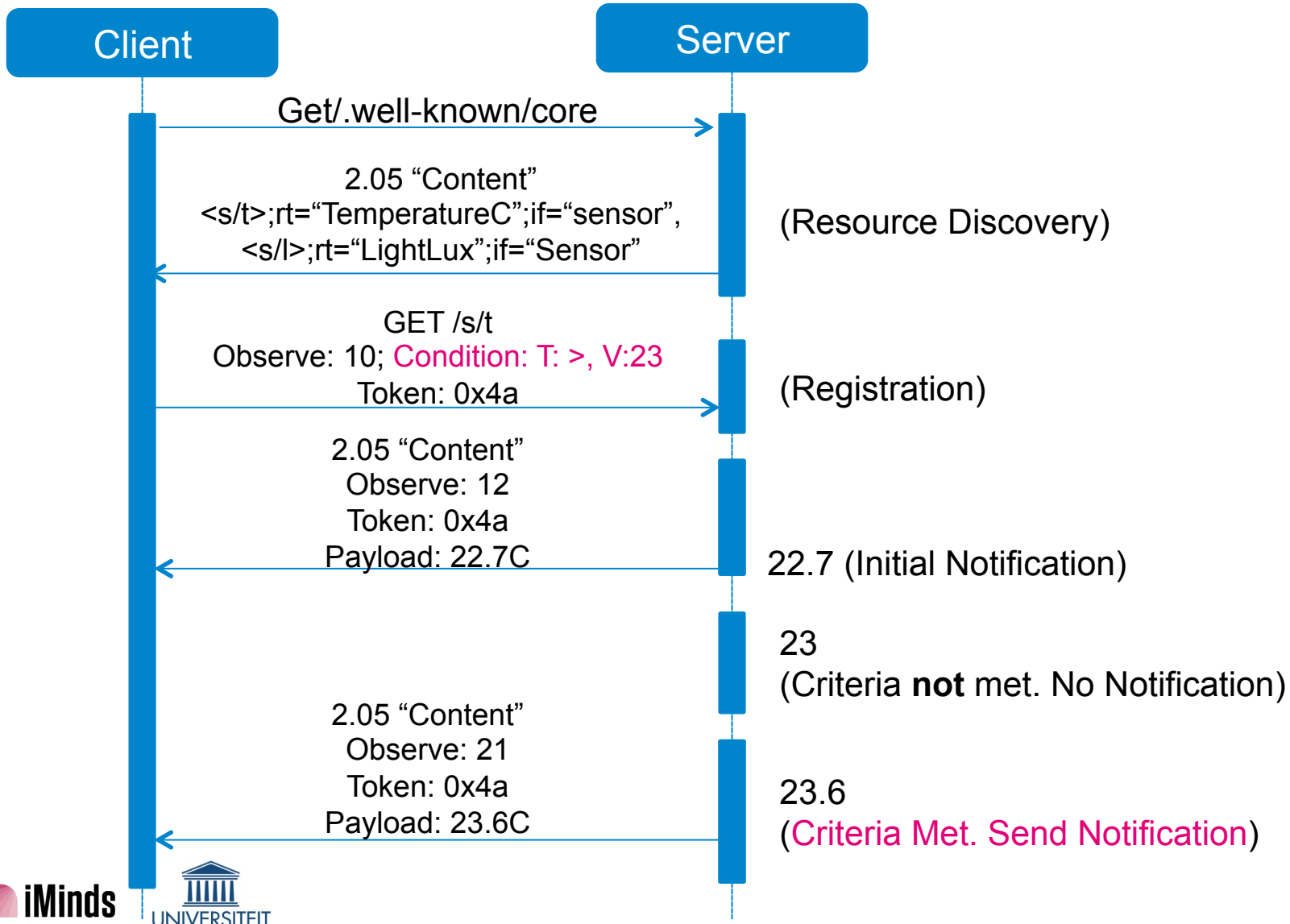


Possible scenario
- Collect data every 30 minutes
- If threshold exceeded, monitor every 5 minutes

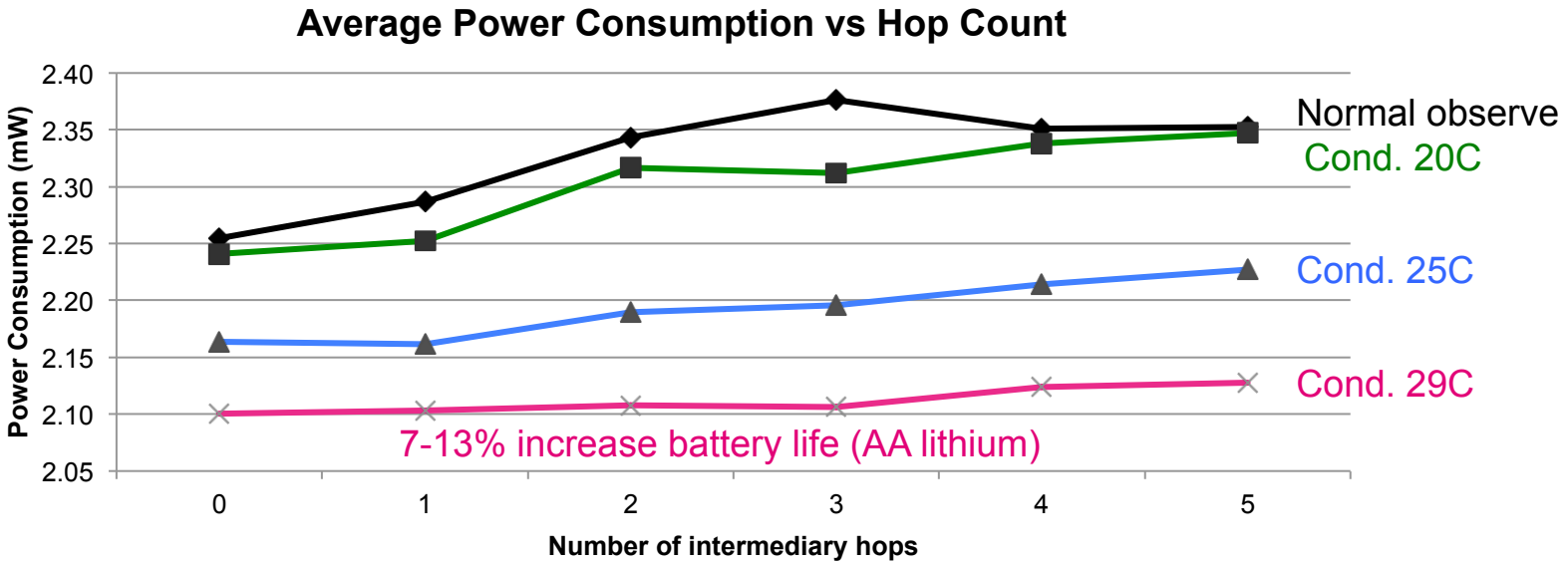
Possible solutions
- Polling
- Observe: collect ALL values and filter

➔ not efficient

CoAP Conditional Observe option



Evaluation: Cooja



- Can greatly reduce traffic compared to observe + client-side filtering:
  - Strongly dependent on the use case (and thus the conditions)
  - More extreme conditions (e.g. alarms) are best
- Implementation on very constrained device feasible

Almost RFC

RFC-Editor's Queue:

draft-ietf-core-coap -18 2013-06-28 RFC Ed Queue 1/174

CoRE Working Group
Internet-Draft
Intended status: Standards Track
Expires: December 30, 2013

Z. Shelby
Sensinode
K. Hartke
C. Bormann
Universitaet Bremen TZI
June 28, 2013

Constrained Application Protocol (CoAP)
draft-ietf-core-coap-18

Abstract

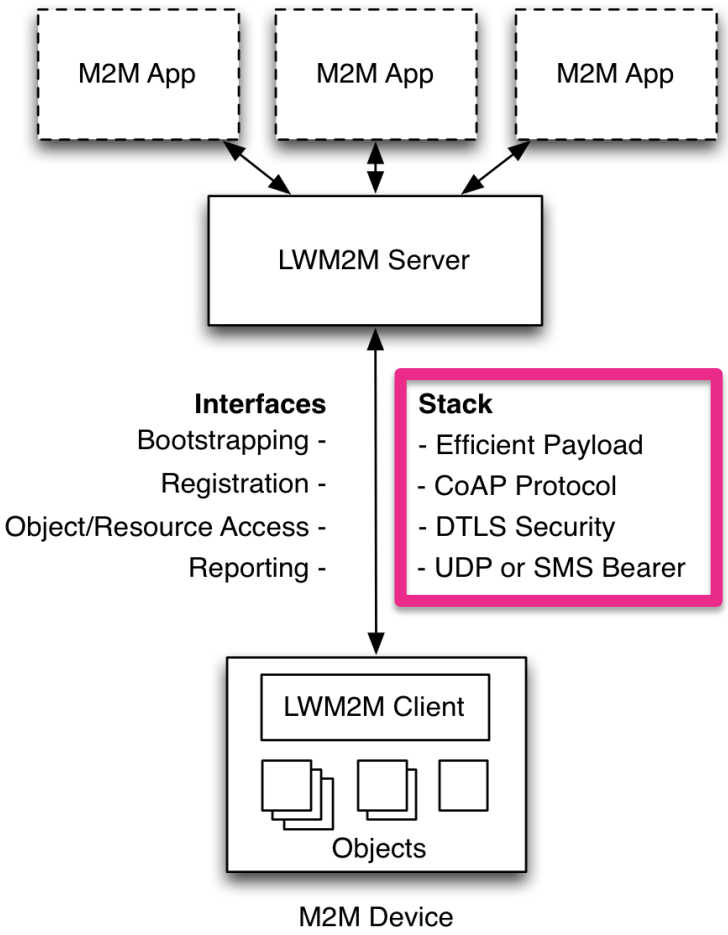
The Constrained Application Protocol (CoAP) is a specialized web transfer protocol for use with constrained nodes and constrained (e.g., low-power, lossy) networks. The nodes often have 8-bit microcontrollers with small amounts of ROM and RAM, while constrained networks such as 6LoWPAN often have high packet error rates and a typical throughput of 10s of kbit/s. The protocol is designed for machine-to-machine (M2M) applications such as smart energy and building automation.

CoAP provides a request/response interaction model between application endpoints, supports built-in discovery of services and resources, and includes key concepts of the Web such as URIs and Internet media types. CoAP is designed to easily interface with HTTP for integration with the Web while meeting specialized requirements such as multicast support, very low overhead and simplicity for constrained environments.

- Primary advocate for IP networked devices
- Non-profit association of more than 60 members
- IPSO Application framework:
  - REST interfaces for smart objects on top of CoAP

Atmel
BOSCH
Invented for life
CISCO
COOPER Power Systems
Duke Energy
dust networks™
EDF
ERICSSON
freescale semiconductor
greenWAVE
Itron
Landis+Gyr
manage energy better
NIVIS
NXP
Proto6
SIGMA DESIGNS
sensinode
SILVERSPRING
SILICON LABS
SWEDISH ICT SICS
life.augmented
TOSHIBA
Leading Innovation
TRIDIUM
EPRI ELECTRIC POWER RESEARCH INSTITUTE
Google
ISMB Istituto Superiore Mario Boella
Aidon
Reply concept
Connected by CONNODE
LULEÅ UNIVERSITY OF TECHNOLOGY
MAXFOR(주)맥스포 MAXFOR Technology Inc.
NOKIA Connecting People
CyberLightning
econocom MOBILITY ON DEMAND
ELECTROTEST Sweden AB
SENSUS
SYNAPSE
TAMPERE UNIVERSITY OF TECHNOLOGY
elko
elster
EMERSON Climate Technologies
TEXAS INSTRUMENTS
TMC
United Technologies Research Center

- OMA Lightweight M2M (LWM2M)
  - Efficient Device-Server interface based on open IETF standards
  - Standard published December 2013



OMA Lightweight M2M

Get Your FREE Specification for M2M Device Management

Lightweight M2M from the Open Mobile Alliance is fast becoming the global industry standard for M2M device management for the development of a fast, deployable, client-server specification to provide machine-to-machine service.

As the interface between M2M device and M2M Server, Lightweight M2M provides the best choice for the M2M Service Provider to deploy an M2M system to provide service to the M2M user.

OMA Lightweight M2M is designed to:

- Provide Device Management functionality over sensor or cellular networks
- Transfer service data from the network to devices
- Extend to meet the requirements of most any application

Interoperability testing ongoing

CoAP 3 & OMA Lightweight M2M

Las Vegas, USA, 19-22 November 2013

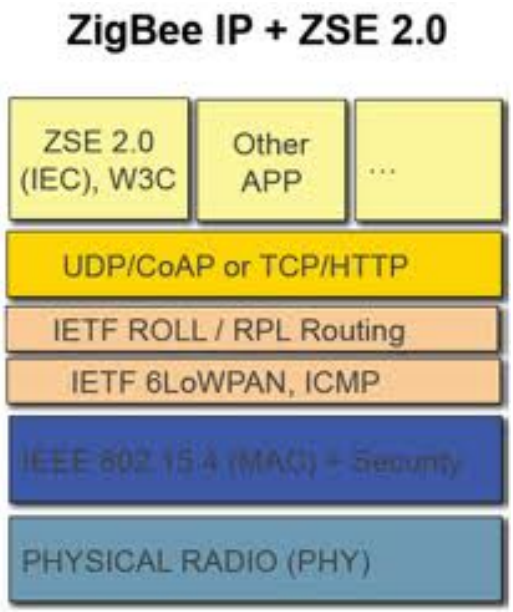
ETSI Plugtests™, the IPSO Alliance and the Open Mobile Alliance (OMA), are pleased to invite you to participate in the next CoAP and Lightweight M2M interoperability test event taking place from 19-22 November 2013 in Las Vegas, USA. The event is co-located with the OMA AGM, Board, Technical Plenary and Working Group meetings.

4th Plugtest : March 7-9, London

Co-organized by ETSI, the IPSO Alliance and OMA

Zigbee IP Specification

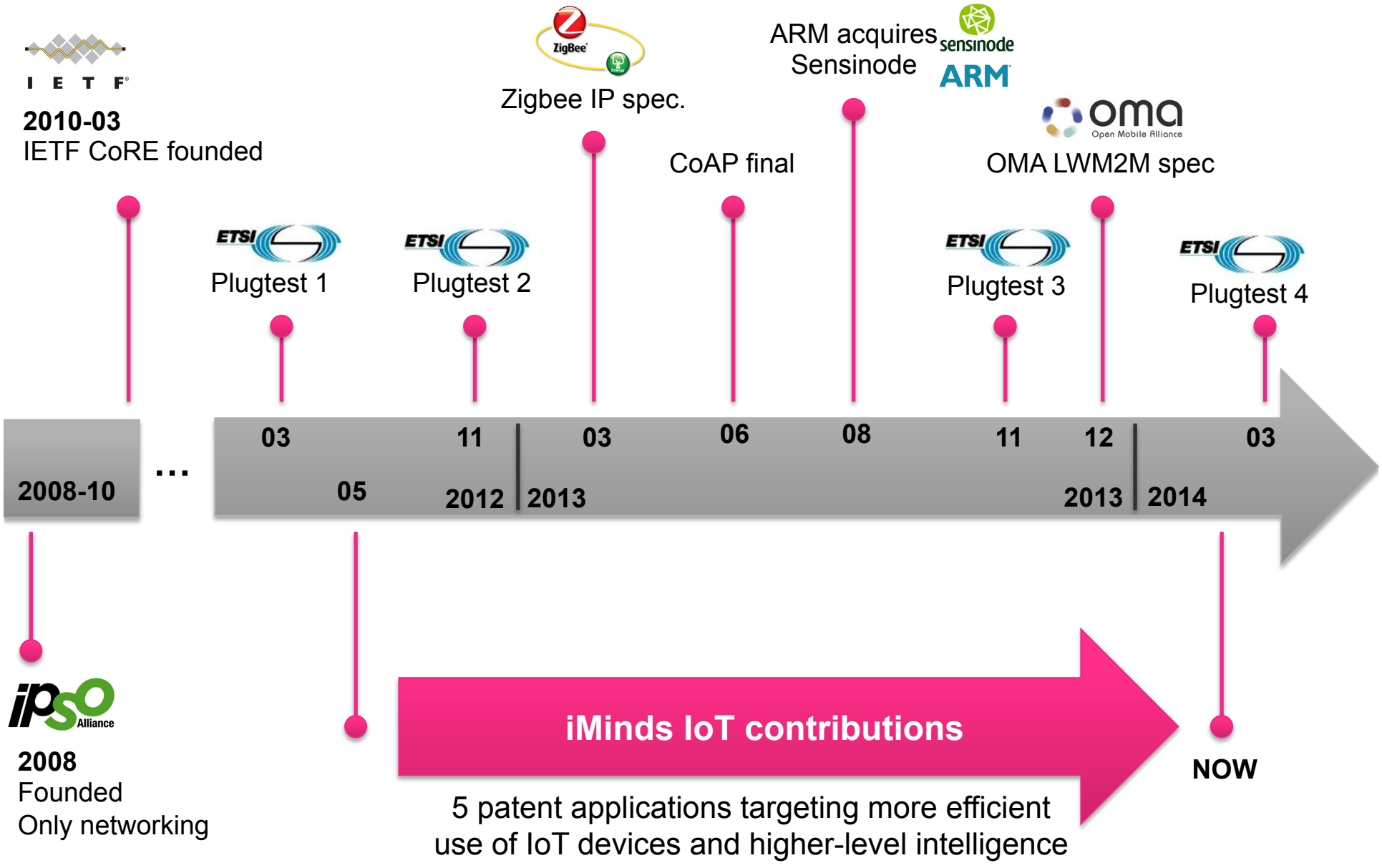
- "ZigBee Alliance member companies recognized the need to develop a ZigBee-based IP stack to complement the efforts within IETF"



"Some optimizations are simple, such as the use of UDP instead of TCP and moving from HTTP to Constrained Application Protocol (CoAP) to reduce messaging overhead."

"Compressing headers using new formats such as CoAP is a more battery-friendly approach."

Skip Ashton, Chair of the ZigBee Architecture Review Committee


IETF
2010-03
IETF CoRE founded
ZigBee
Zigbee IP spec.
ARM acquires Sensinode
sensinode
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Open Mobile Alliance
OMA LWM2M spec
CoAP final
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Plugtest 4
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ipso Alliance
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Founded
Only networking
iMinds IoT contributions
NOW
5 patent applications targeting more efficient
use of IoT devices and higher-level intelligence
building upon IETF CoRE work
and 3 IETF CoRE contributions
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Towards open horizontal standards

TOMORROW

Domain specific applications

Manu-factoring

Health-care

…

Application enablement

IP connectivity

Reconfigurable technologies

Domain specific devices

…

PLUG & PLAY

auto/ self

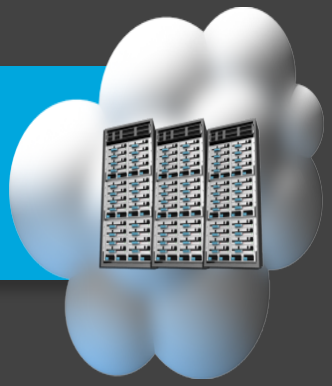
- **configuration**
- **management**
- **diagnostics**
- **healing**

ROBUSTNESS at scale

Distributed intelligence

Traditional Computing Model

Datacenter/Cloud

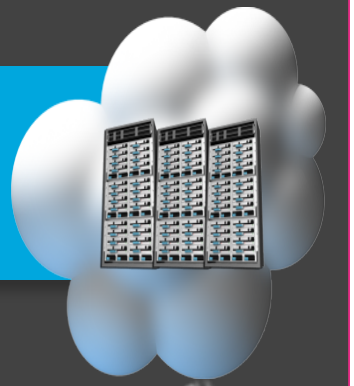


Infinite,bandwidth,
0 delay

Endpoint

IoE Computing Model

Datacenter/Cloud



Assumes limited bandwidth,
variable delay, and
intermittent connectivity

Fog

Assumes limited bandwidth,
variable delay, and intermittent
connectivity

Device

CISCO

Questions ?

Ingrid Moerman
Ingrid.moerman@intec.ugent.be

www.ibcn.intec.ugent.be
Internet Based Communication Networks and Services (IBCN)
Department of Information Technology (INTEC)
Ghent University - iMinds